

CLAIMS

What is claimed is:

Sub 17

1. A system comprising:  
a symbol estimation module for determining, for a multi-dimensional  
5 symbol  $r_k^D$  having  $D$  dimensions, where  $D$  is an integer greater than 1, an  
estimate of the multi-dimensional symbol; and  
a residual determination module coupled to the symbol estimation  
module for determining a residual or a function thereof for the multi-  
dimensional symbol responsive to the multi-dimensional symbol  $r_k^D$  and the  
10 estimate.
2. The system of claim 1 wherein the multi-dimensional symbol estimate  
comprises the vector  $s_k^D$ .
3. The system of claim 1 wherein the multi-dimensional symbol estimate  
15 comprises the scalar  $s_k$ .
4. The system of claim 1 wherein the residual comprises the residual  
vector  $z_k^D$ .
5. The system of claim 1 wherein the residual comprises the scalar  $z_k$ .
6. The system of claim 1 wherein the residual is a phase residual.  
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7. The system of claim 1 wherein the residual is an orthogonal  
component residual.

8. The system of claim 5 wherein the residual  $z_k$  is a composite residual.
9. The system of claim 1 wherein the residual determination module determines a function of the residual vector  $r_k^D$ .
- 5 10. The system of claim 9 wherein the function is the average of the individual components of the residual vector  $r_k^D$ .
- 10 11. The system of claim 1 wherein the system estimation module also determines a reliability metric  $R_k$  for the estimate of the multi-dimensional symbol, and weights the residual or function thereof using the reliability metric.
12. The system of claim 1 further comprising a phase determination module for determining a derotation phase responsive to the residual.
13. The system of claim 12 wherein the derotation phase is the vector  $\theta_k^D$ .
- 15 14. The system of claim 12 wherein the derotation phase is the scalar  $\theta_k$ .
15. The system of claim 1 further comprising a phase determination module for determining a phase offset estimate responsive to the residual.
16. The system of claim 15 wherein the phase offset estimate is the vector  $\Delta\theta_k^D$ .

17. The system of claim 15 wherein the phase offset estimate is the scalar  $\Delta\theta_k$ .

18. The system of claim 12 further comprising a symbol derotator for derotating each of the individual symbols in the vector  $r_k^D$  responsive to the derotation  
5 phase.

19. The system of claim 15 further comprising an accumulator for determining a derotation phase responsive to the phase offset estimate.

20. The system of claim 19 further comprising a symbol derotator for derotating each of the individual symbols in the vector  $r_k^D$  responsive to the derotation  
10 phase.

21. The system of claim 1 wherein the symbol estimation module comprises a decoder capable of producing soft estimates.

22. The system of claim 21 wherein the decoder is a log-MAP decoder.

23. The system of claim 12 wherein the phase determination module updates the derotation phase at the frequency of individual symbols in the multi-dimensional symbol.

24. The system of claim 15 wherein the phase determination module updates the derotation phase once for each multi-dimensional symbol.

25. The system of claims 12 or 15 in a carrier tracking module.

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26. The carrier tracking module of claim 25 in a receiver.

27. The receiver of claim 26 in a communications device.

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28. A set-top box which comprises the communications device of claim

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29. A system comprising:

a symbol estimation module for determining, for a multi-dimensional symbol  $r_k^D$  having  $D$  dimensions, where  $D$  is an integer greater than 1, an estimate of the multi-dimensional symbol;

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a residual determination module coupled to the symbol estimation module for determining a residual or a function thereof for the multi-dimensional symbol responsive to the multi-dimensional symbol  $r_k^D$  and the estimate; and

a phase determination module for determining a derotation phase or phase offset estimate for the multi-dimensional symbol responsive to the residual or function thereof.

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30. The system of claim 29 further comprising a symbol derotator for derotating each of the individual symbols in the multi-dimensional symbol  $r_k^D$  responsive to the derotation phase.

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31. The system of claim 29 further comprising an accumulator for determining a derotation phase for the multi-dimensional symbol responsive to the phase offset estimate.

32. The system of claim 31 further comprising a symbol derotator for derotating each of the individual symbols in the multi-dimensional symbol responsive to the derotation phase.

33. A system comprising:

5 symbol estimation means for determining, for a multi-dimensional symbol  $r_k^D$  having D dimensions, where D is an integer greater than 1, an estimate of the multi-dimensional symbol;

10 residual determination means coupled to the symbol estimation means for determining a residual or a function thereof for the multi-dimensional symbol responsive to the multi-dimensional symbol  $r_k^D$  and the estimate.

34. A method comprising the steps of:

determining, for a multi-dimensional symbol, an estimate of the symbol; and  
determining, responsive to the estimate, a residual or a function thereof.

15 35. The method of claim 34 wherein the multi-dimensional symbol estimate comprises the vector  $s_k^D$ .

36. The method of claim 34 wherein the multi-dimensional symbol estimate comprises the scalar  $s_k$ .

20 37. The method of claim 34 wherein the residual comprises the residual vector  $z_k^D$ .

38. The method of claim 34 wherein the residual comprises the scalar  $z_k$ .

39. The method of claim 34 wherein the residual is a phase residual.

40. The method of claim 34 wherein the residual is an orthogonal component residual.

5 41. The method of claim 38 wherein the residual  $z_k$  is a composite residual.

42. The method of claim 34 further comprising determining a function of the residual vector  $r_k^D$ .

10 43. The method of claim 34 further comprising determining the average of the individual components of the residual vector  $r_k^D$ .

44. The method of claim 34 further comprising determining a reliability metric  $R_k$  for the estimate of the multi-dimensional symbol, and weighting the residual or function thereof using the reliability metric.

15 45. The method of claim 34 further comprising determining a derotation phase responsive to the residual.

46. The method of claim 45 wherein the derotation phase is the vector  $\theta_k^D$ .

20 47. The method of claim 45 wherein the derotation phase is the scalar  $\theta_k$ .

48. The method of claim 34 further comprising determining a phase offset estimate responsive to the residual.

49. The method of claim 48 wherein the phase offset estimate is the vector  $\Delta\theta_k^D$ .

50. The method of claim 48 wherein the phase offset estimate is the scalar  $\Delta\theta_k$ .

5 51. The method of claim 45 further comprising derotating each of the individual symbols in the vector  $r_k^D$  responsive to the derotation phase.

52. The method of claim 48 further comprising determining a derotation phase responsive to the phase offset estimate.

10 53. The method of claim 52 further comprising derotating each of the individual symbols in the vector  $r_k^D$  responsive to the derotation phase.

54. The method of claim 45 further comprising updating the derotation phase at the frequency of individual symbols in the multi-dimensional symbol.

15 55. The method of claim 45 further comprising updating the derotation phase once for each multi-dimensional symbol.

56. A computer readable medium tangibly embodying any of the methods of claims 34-55.

20 57. The computer readable medium of claim 56 which comprises a memory.

58. Circuitry which tangibly embodies any of the methods of claims 34-55.